GBT MEMO 199

Field-of-View of the GBT at 90 GHz

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In order to study 90 GHz feed array performance of the GBT at the secondary focus, Srikanth has done simulations of the antenna patterns for various feed offsets from the secondary focus position, using Jacobi-Bessell Geometric Theory of Diffraction analysis software. From experience with similar calculations at lower frequencies, the offset direction that results in the fastest beam degradation is within the antenna symmetric plane, toward the primary reflector. For small feed offsets, this throws the beam in elevation at the rate of approximately 10.6 arcsec per centimeter of offset.

A 40-52 GHz corrugated feedhorn has already been designed, fabricated, and tested for the GBT Q-band Array Receiver. This feed has an outside diameter of slightly less than 4.5 cm, 6.4 wavelengths. For the purpose of this study, a scaled version of this feed was taken as a prototypical feedhorn size. The resulting beamwidth of the GBT is approximately 8 arcseconds, and spacing the feedhorns at 2.25 cm center-center results in a beam spacing on the sky of about 24 arcseconds.

As a practical matter, an array receiver should be designed to fit within one of the 24 inch (60 cm) or 36 inch (90 cm) diameter feed mounting rings on the GBT receiver turret. For illustration, Figure 1 shows a circular array with 169 of the prototype feedhorns. The radius of each ring of feeds is 2.25 cm larger than the previous ring. The number of feeds in each ring progresses in the fashion: 6, 12, 18, 24, etc. No effort was made to optimize the feed layout for scientific needs or to look into whether such dense packaging of the receiver electronics is practical.

Table 1 summarizes the results of the GTD simulations. Given is the feed offset from the on-axis focus position (in cm and wavelengths), the resulting beam throw (in arcseconds and number of HPBW's), the HPBW (in arcseconds) for two cuts through the main beam, the antenna gain (in dB), and the efficiency (in percent). The final Beams column gives the approximate number of prototype feedhorns that could be packed within a circle with radius equal to the stated feed offset. The given efficiency includes taper and illumination efficiency, plus scan loss if any, but does not include surface efficiency or other terms. The feed offset direction is in the antenna symmetric plane, toward the primary reflector. The third line in Table 1 gives the approximate worst-case performance that would be expected for the outer ring of feeds in Figure 1. As a point of reference, it was found that the coma lobe level is approximately -15dB for an offset of 33.3 cm (the fourth line of Table 1).

Figures 2 through 7 shows two pattern cuts through the GBT beam at each offset in Table 1. The Elevation cut is that which would be measured by scanning the GBT in elevation and holding azimuth fixed. The Cross-Elevation cut is orthogonal to the Elevation cut. Note that the on-axis feed gives sidelobes below -30 dB. Figure 4 gives patterns similar to that which would be expected by feeds on the outer ring of Figure 1. The coma lobe in the elevation cut is at about the -20dB level and the cross-elevation cut has broadened slightly.

TABLE 1

GBT Beam Scan Performance at 90 GHz
Feed in Symmetric Plane, Offset Toward Primary

Feed Offset		Beam Width		Beam Throw		Gain	Efficiency	Beams
(cm)	(λ)	(Arcsec) X-El	El	(Arcsec)	(HPBW)	(dB)	(%)	
0.0	0.0	8.4	8.2	0.0	0.0	97.81	67.84	1
8.4	25.0	8.1	8.3	89.6	10.8	97.81	67.84	37
15.75	47.3	8.2	8.3	170.1	20.6	97.78	67.46	169
33.3	100.0	8.5	8.4	362.0	43.8	97.22	59.31	631
41.6	125.0	8.7	8.5	453.4	54.8	96.75	53.22	1027
50.0	150.0	8.9	8.9	545.6	66.0	96.05	45.26	1519

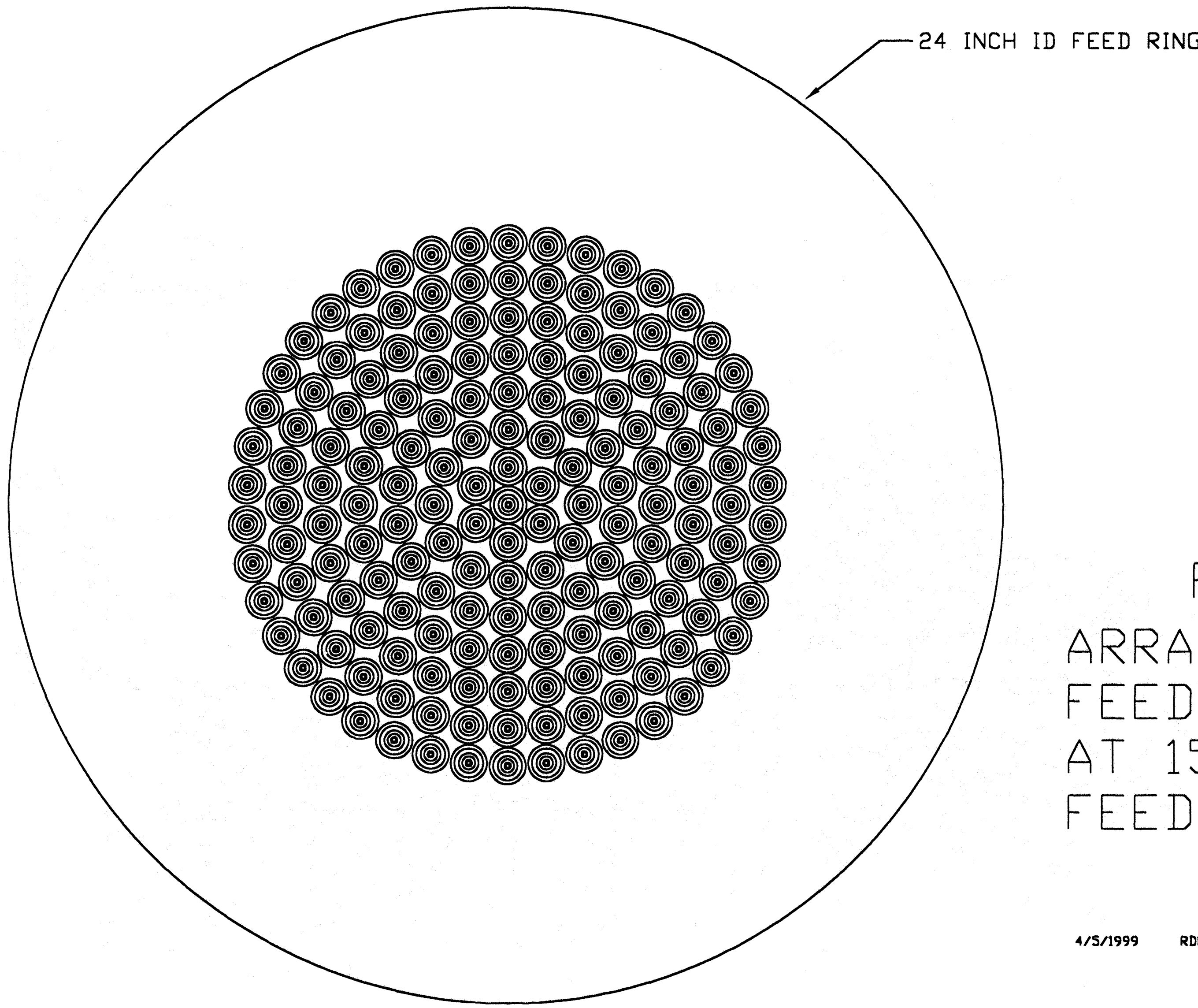

FIGURE 1

ARRAY OF 169 3.5mm FEEDS. OUTER RING AT 15.75cm OFFSET. FEED OD 2.25cm.

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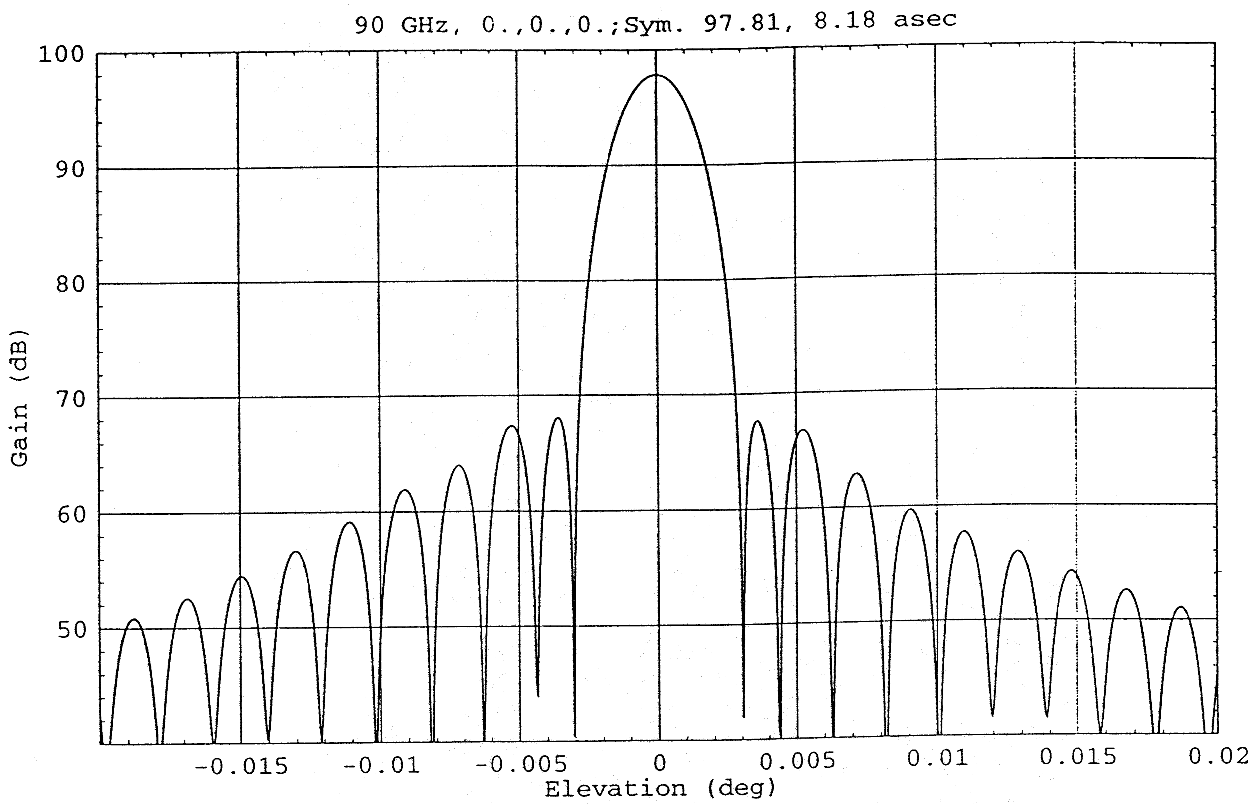
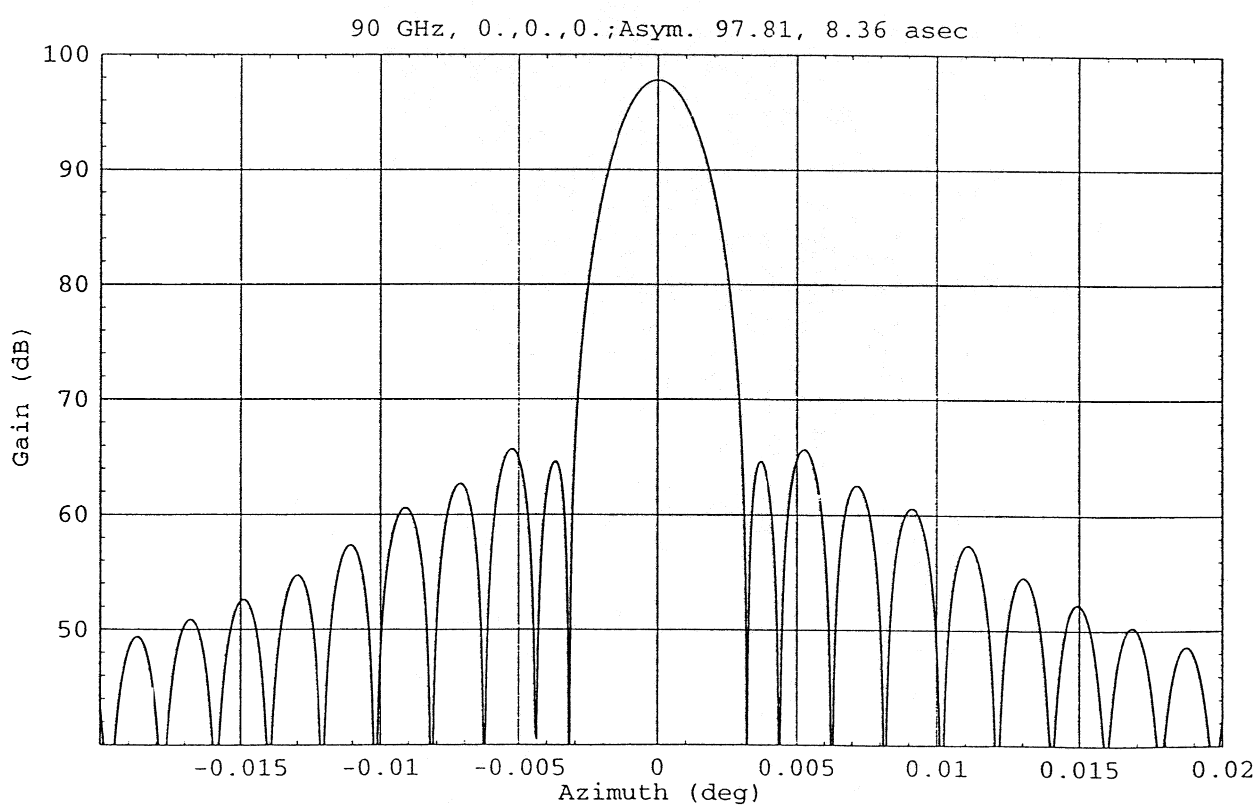
FIGURE 2
90 GHz Feed on Boresight

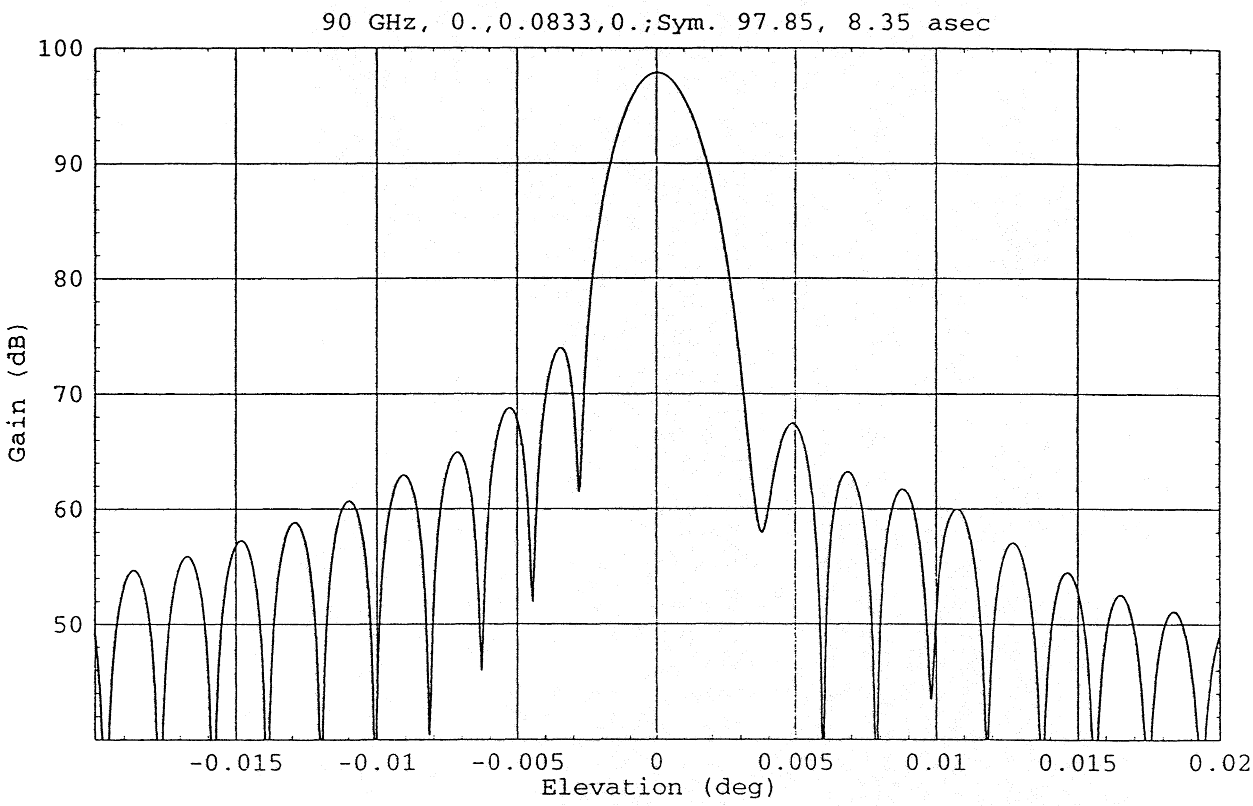


a) Pattern Cut, Elevation

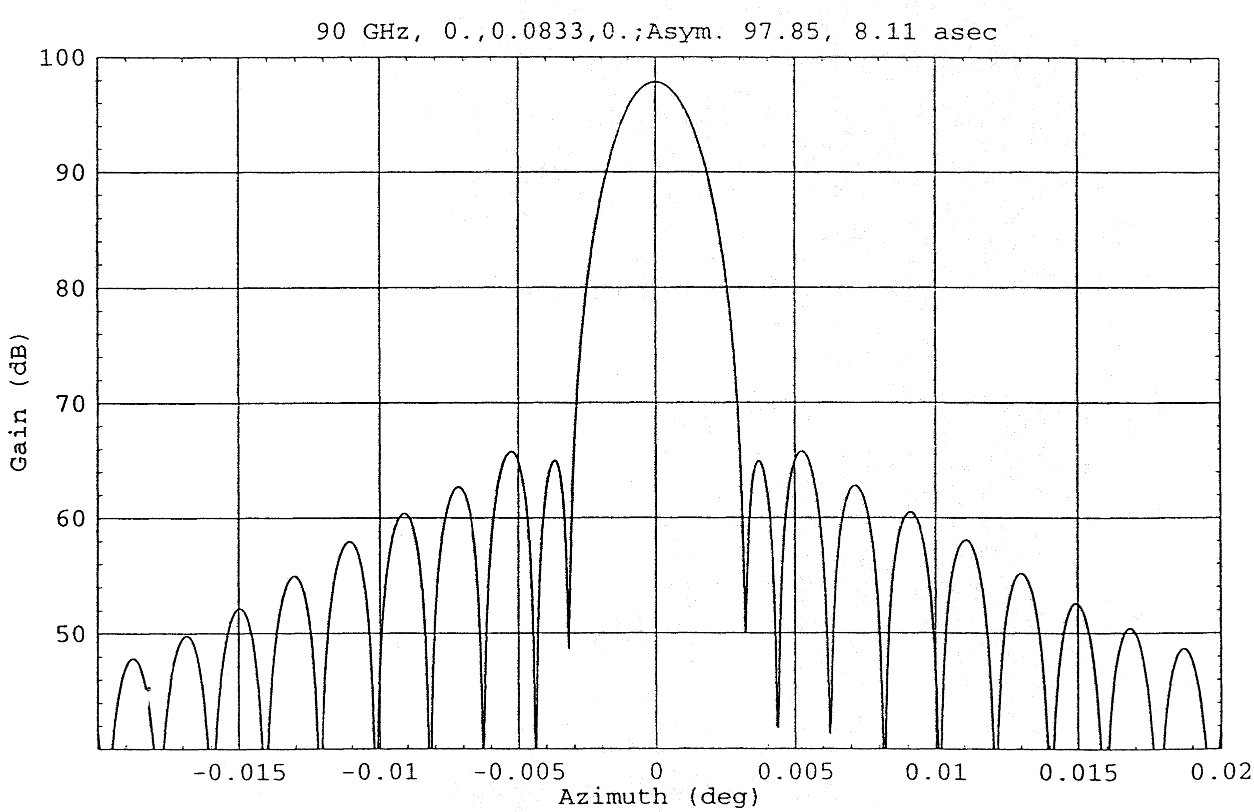


b) Pattern Cut, Cross-Elevation

FIGURE 3
90 GHz Feed Offset
8.3 cm Toward Primary

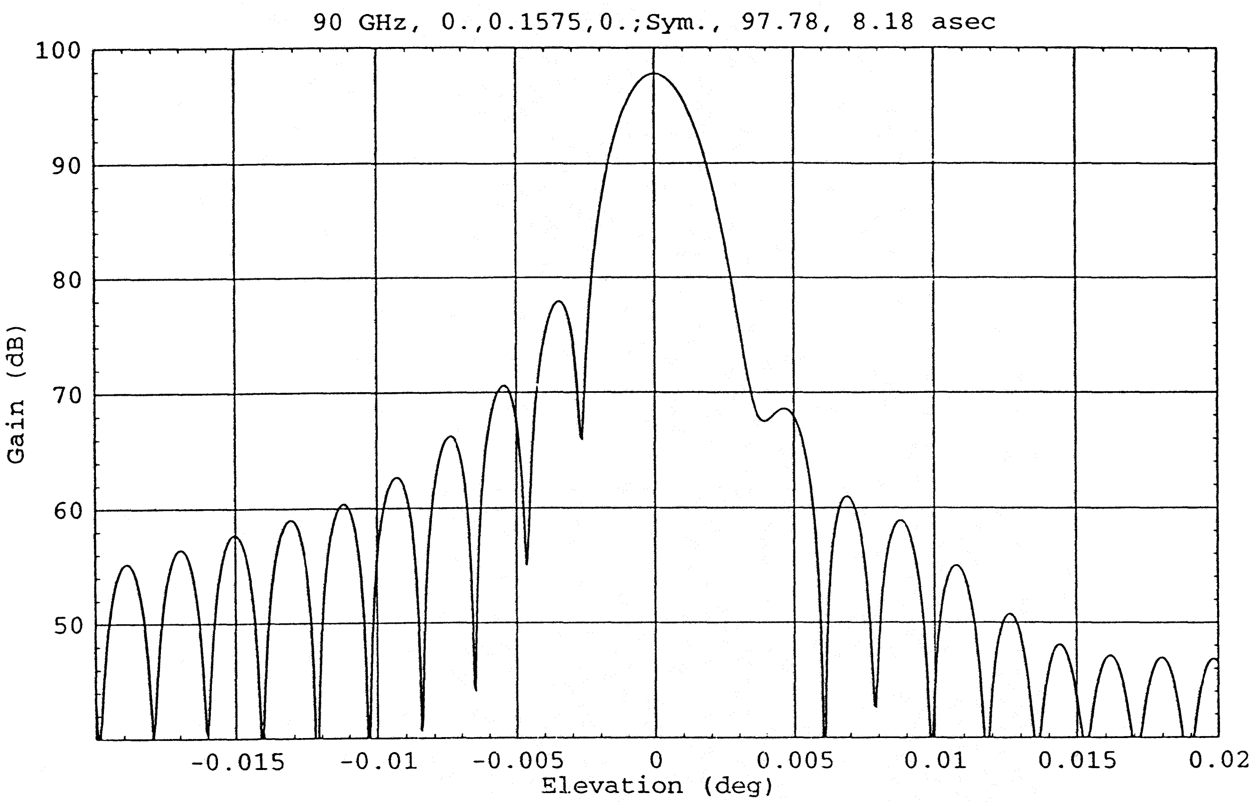


a) Pattern Cut, Elevation

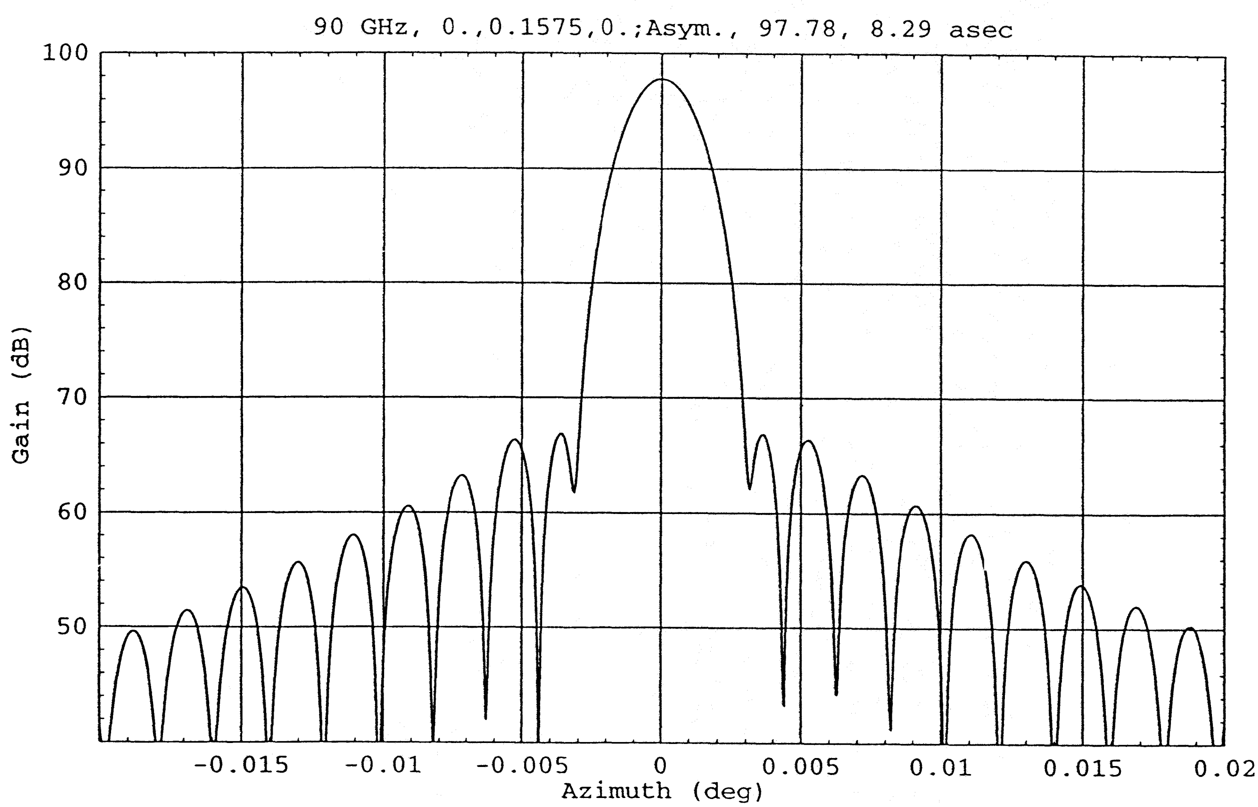


b) Pattern Cut, Cross-Elevation

FIGURE 4
90 GHz Feed Offset
15.75 cm Toward Primary

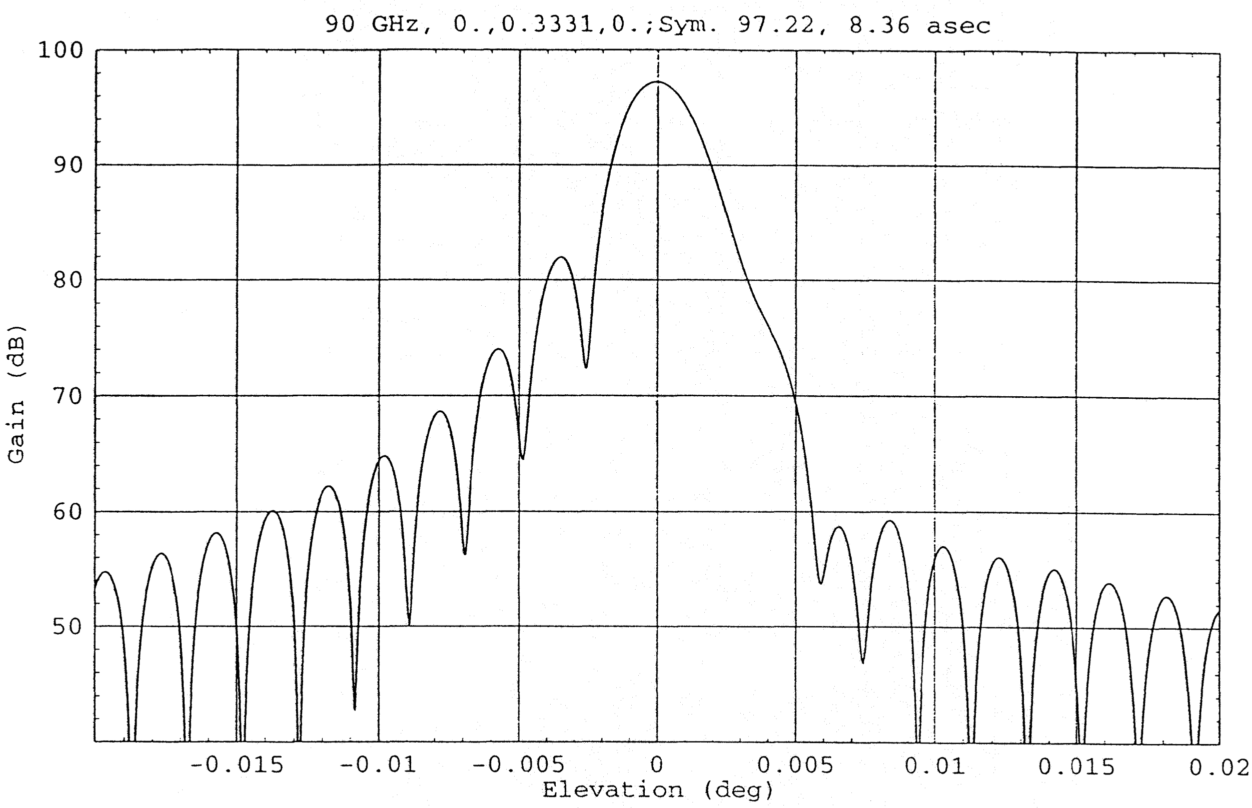


a) Pattern Cut, Elevation

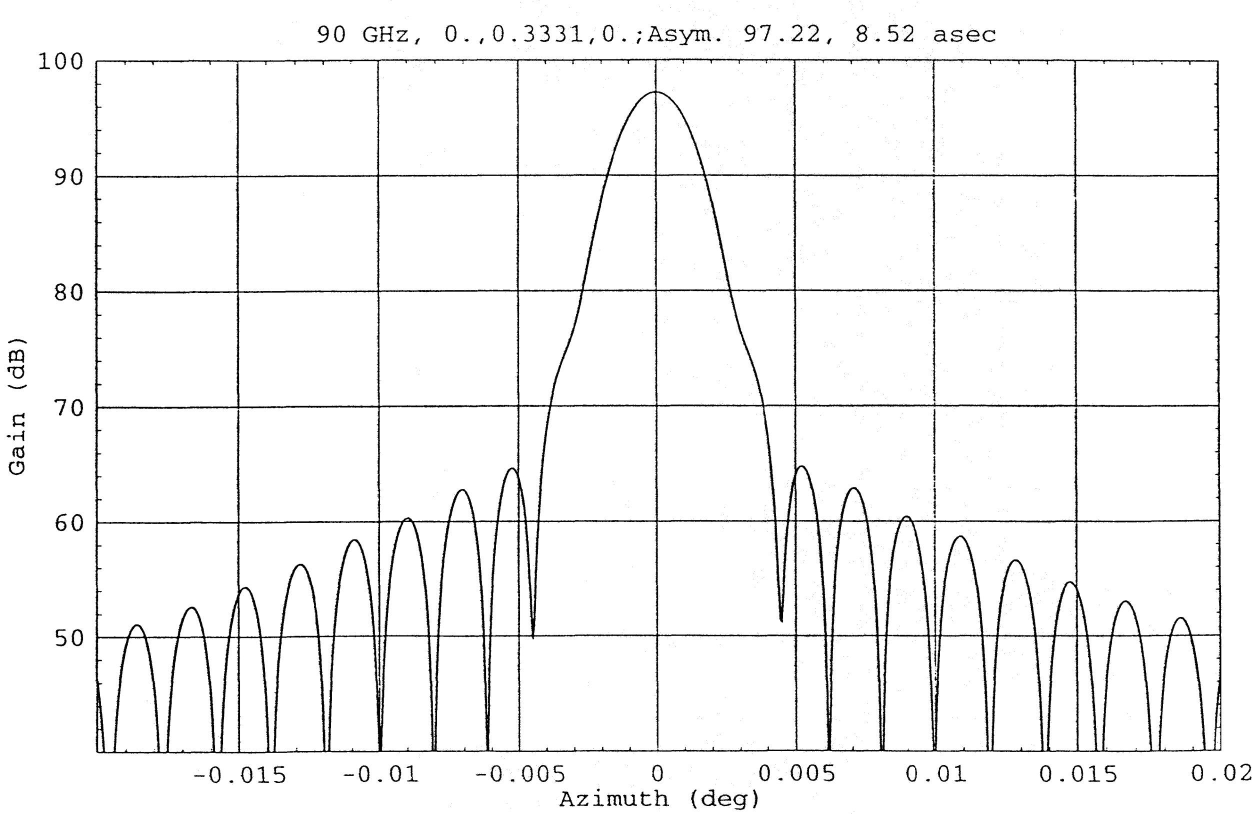


b) Pattern Cut, Cross-Elevation

FIGURE 5
90 GHz Feed on Boresight
33.3 cm toward Primary

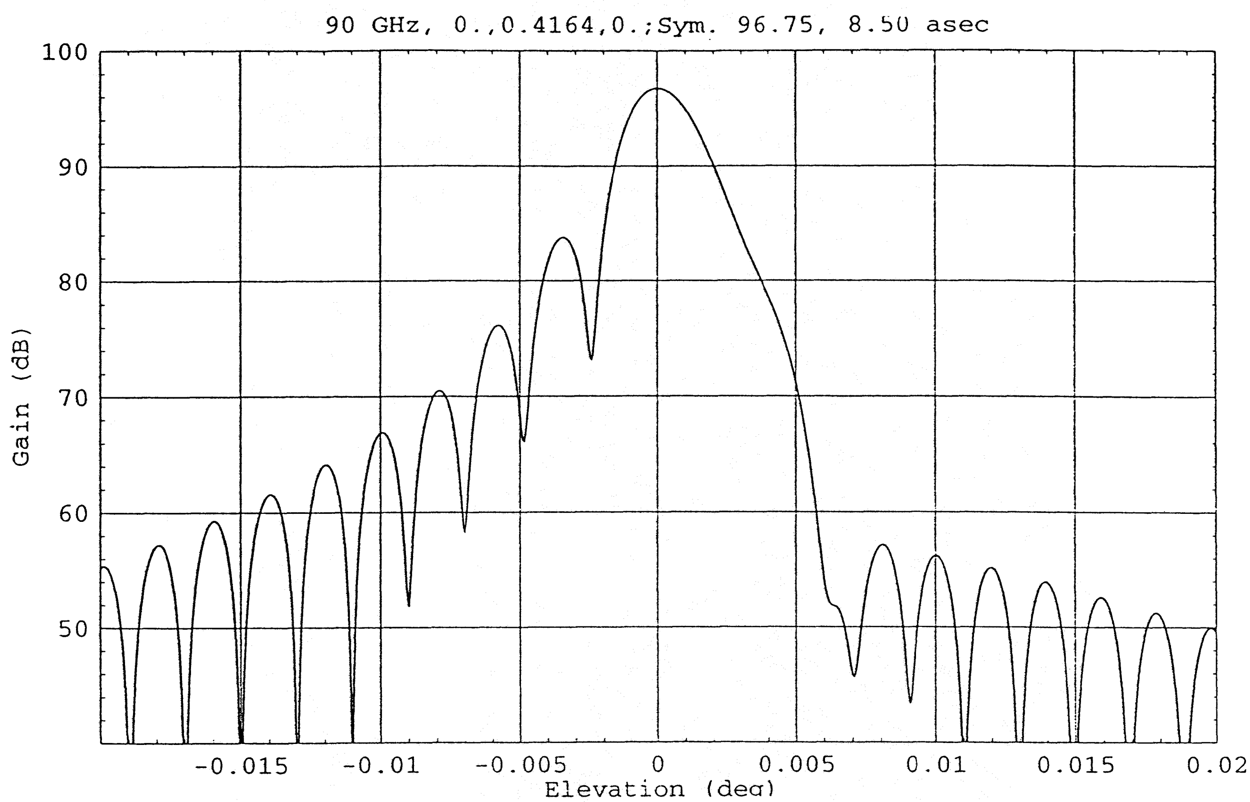


a) Pattern Cut, Elevation

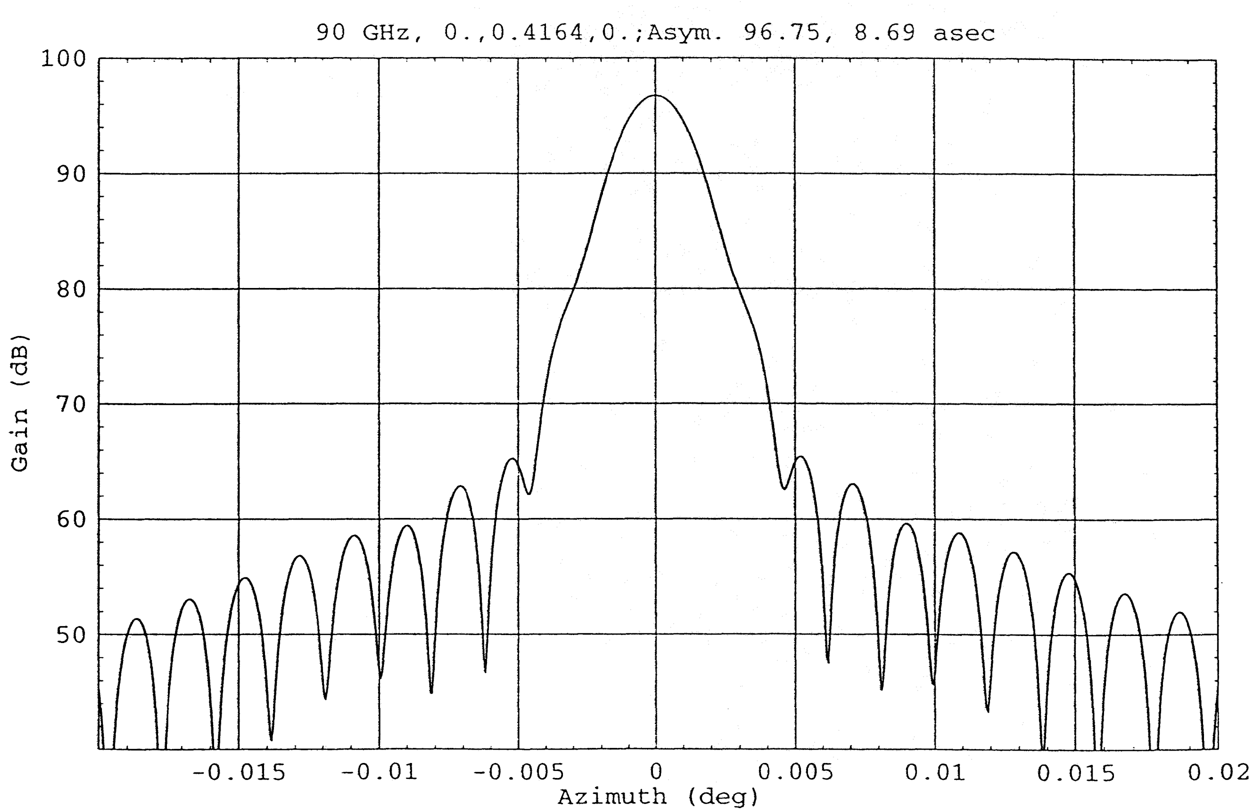


b) Pattern Cut, Cross-Elevation

FIGURE 6
90 GHz Feed Offset
41.6 cm Toward Primary

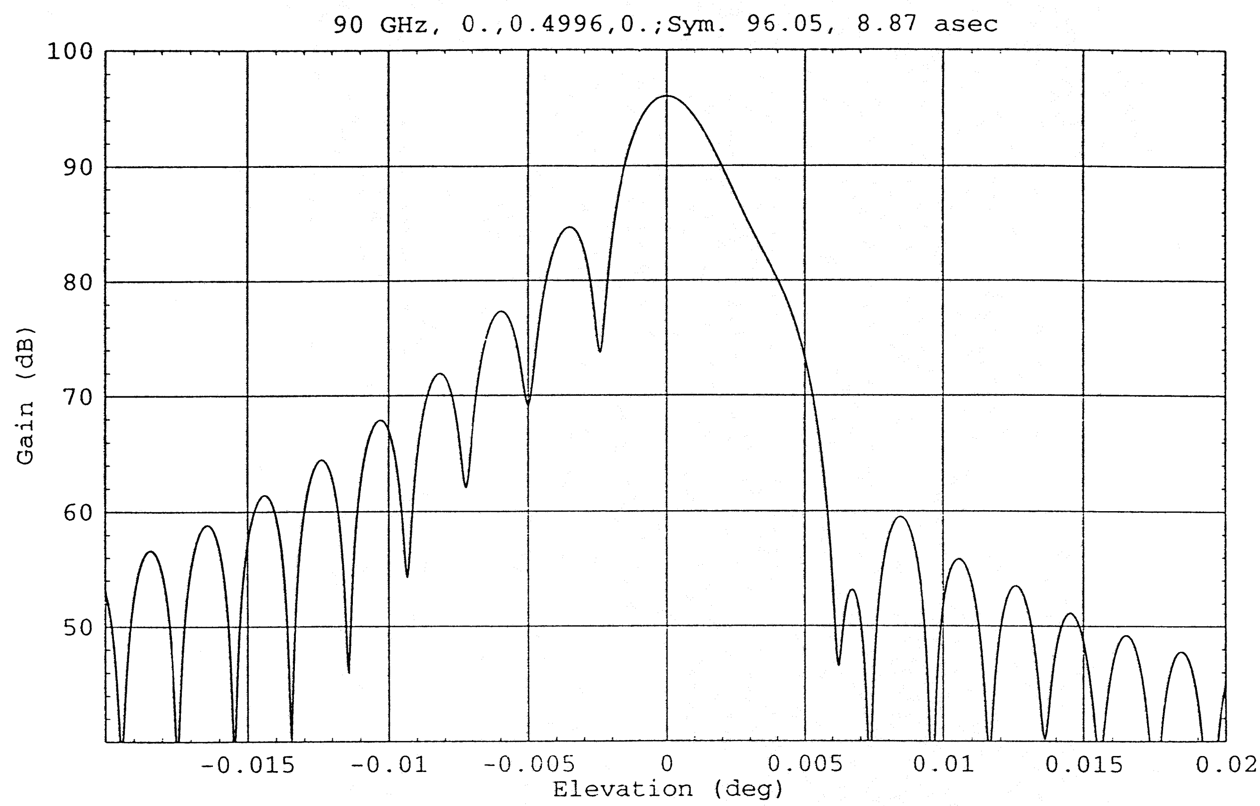


a) Pattern Cut, Elevation

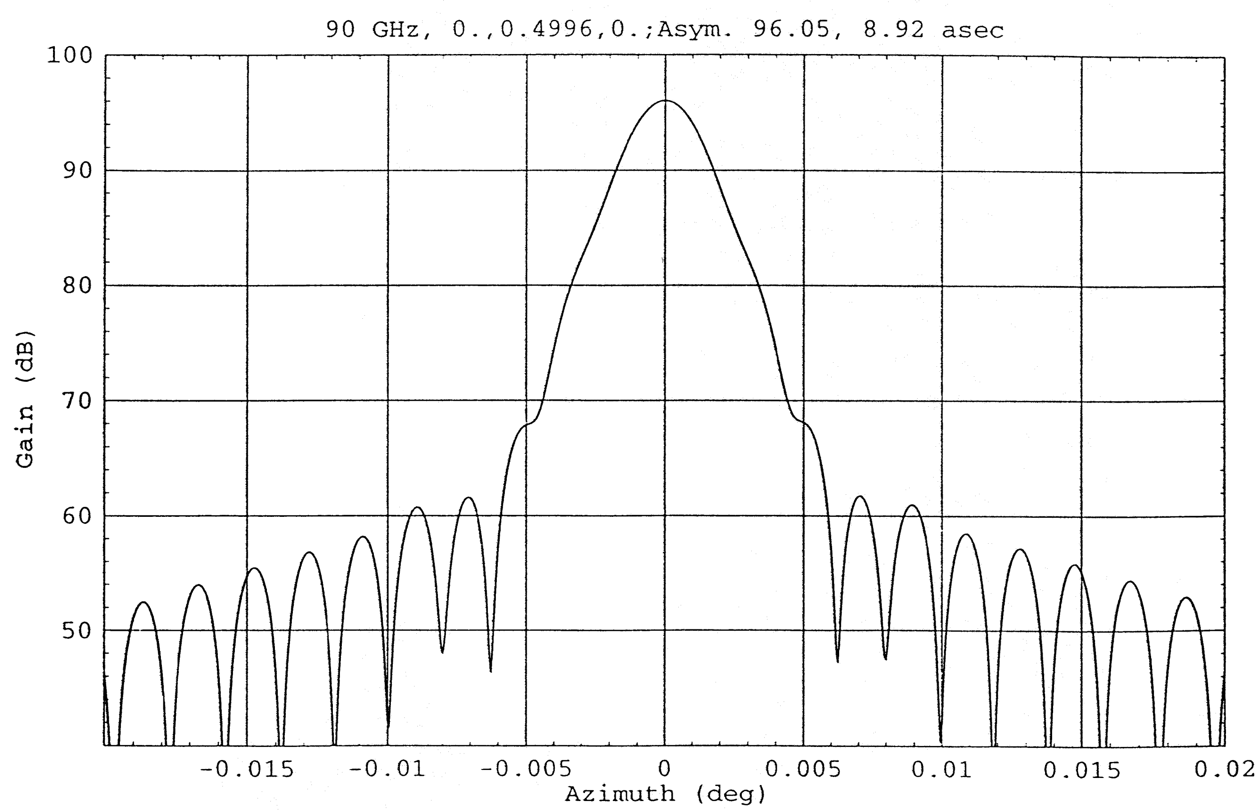


b) Pattern Cut, Cross-Elevation

FIGURE 7
90 GHz Feed Offset
50 cm Toward Primary



a) Pattern Cut, Elevation



b) Pattern Cut, Cross-Elevation